A L1 FE Trigger
for the Forward Preshower Detector
Design Version 1

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Cluster and Track Algorithms

Each layer of the forward preshower, FPS, is made of interlocking triangular scintillating strips. See Figure 1. Each minimum ionizing particle will transit a constant thickness of scintillator but because the layer is divided into triangular cross section strips the light output us shared by a random fraction between any two strips.

The forward preshower is made up of four of these layers. The first two layers are U(L1) and V(L2) stereo layers which will see MIPs from electrons. A lead radiator is located behind the first two layers and before the third (L3) and forth (L4) layers. This lead will convert most electrons into showers. See figures 2 and 3. While a MIP is 1 to 2 strips wide a shower is 2 to 6 strips.

The FPS is divided into 16 sections and covers an eta range from 1.4 to 2.6. Therefore the delta phi subtended by each section is 0.4 and the delta eta subtended is 1.2. To match the 0.1 delta phi structure of the calorimeter towers each sector would need to be sub-divided into 4 phi sectors. And to match the 0.1 delta eta structure it would need to be sub-divided into 16 radial or eta sectors. Since these radial sectors would be on average ~8 strips wide, it would be possible to vary the radial width to achieve more equal bins in delta eta.

A trigger for this detector must first create clusters in each of the four layers, a mip cluster in the first two and an electron shower cluster in the final two. Define a mip cluster as a logical OR of two adjacent strips at a low threshold, L, in each layer and can be represented as;

$$MU(i) = L1(i) \; OR \; L1(i+1)$$

Where i goes from 1 to the number of strips in a layer – 1, L indicates a low threshold on the strip, M stands for a MIP cluster and U for the u-stereo layer. A similar equation holds for the second layer MV.

An electron shower cluster is three strips wide at a high threshold, H, vetoed by a low threshold, L, strip on each side. Its form is[1];

$$EU(j) = H3(j-1) \; AND \; H3(j) \; AND \; H3(j+1)$$
$$AND \; NOT\{L3(j+2)\} \; AND \; NOT\{L3(j-2)\}$$

Where j goes from 1 to the number of strips in the layer. Special truncated forms of this equation are needed for clusters near the inner and outer edges of the layer. A similar equation is formed for the EV layer L4.

When the clusters for each layer have been formed a track is formed by combining clusters from all four layers. A track equation is defined as:

$$T(ijkl) = MU(i) \text{ AND } MV(j) \text{ AND } EU(k) \text{ AND } EV(l)$$

For each value of i there are from 2 to about 32 values of j, exactly the number of V strips crossing each U strip. The same holds true for the relationship between k and l. See figure 4. For now we are only allowing for one value of k for each value of i. That is a diamond in L1/L2 is projected onto only one diamond in L3/L4.

Hardware Description

Each sector of L1, L2, L3, L4 panels uses one VLPC cassette which has 1024 channels. The electronics for each cassette are located on two adjacent CPS FE boards. Layer L1 and L2 each have 132 strips. Panels L3 and L4 each have 192 strips. *This gives a total of 648 channels. There are 16 cassettes available which means that two sectors must fit into one cassette. Too many channels! 648 is more than 512! Maybe I have bad info.* To estimate the number of terms in the cluster finder and track finder make the following assumptions. First the layers are close together relative to the vertex, therefore a cluster in L1/L2 projects onto only one cluster in L3/L4. Second that only strips 1 through 132 in layers L3 and L4 are shadowed by L1 and L2 and the rest are not used in the trigger. Then the number of mip clusters are

132 U strips x <23> overlapping V strips = 3000

The number of track equations is then;

3000 mip clusters x 1 shower cluster per = 3000

Which is a relatively small number.

The next problem is encoding the track information and getting it out of the trigger hardware. An ideal output would be a 0.1 by 0.1 eta by phi pad. That according to the above is 64 separate pads per sector, 4 phi bins by 16 eta bins. The first step is to reduce the 3000 equations down to the 64 pads. At this step about 50 equation outputs are ORed together for each pad. If we stopped here we would need a 64 bit wide ROM to convert from pad bits to a list of tracks with eta and phi 'addresses'. That is not feasible. The second step is to reduce the 64 pixels to 8 by OR'ing together so that 4 phi bins become 2 and 16 eta bins become 4. At this point the ROM is only 8 bits wide which is achievable with the envisioned hardware.

Summary

A design is presented for the L1 trigger for the FPS. This design can be implemented in PLDs in a manner similar to that planned for the L1 CFT/CPS. This first pass design can be used to construct the PLD code and determine the magnitude of the hardware resources necessary. This design has also pointed out some mismatches between the planned detector topology and the natural fit into the readout electronics and trigger hardware. Discussions to resolve these mismatches are indicated. Or perhaps only my education as to the real geometry is necessary.

A maximum of 8 tracks would be reported out from each sector. Globally this is 128 tracks from each end. The bin size or position resolution on these tracks is 0.2 in delta phi and 0.3 in delta eta. A total of 128 tracks is probably more than enough to satisfy any physics needs but one should remember that the two track resolution is only 0.2 (phi) by 0.3 (eta).

In addition there is some discussion as to the absolute orientation of the sections.[2] A proposal has been made to rotate them 6 degrees relative to the calorimeter. There is one section each 22.5 degrees. If the 6 degrees becomes ½ of that, 11.25 degrees, then boundaries of the two line up. Or if the FPS is rotated ¼ of a section or 5.625 degrees the boundaries line up.

References

[1]   Armaud Lucotte, Private communication about how the test beam data is being clustered.
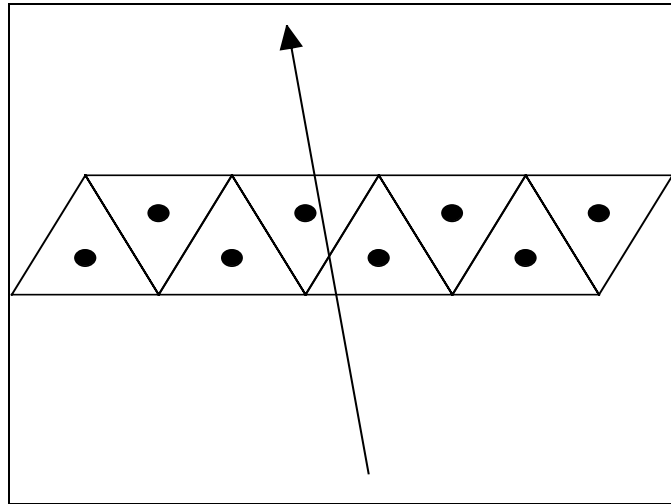[2]   Jon Kotcher, private communication, e-mail, dated 10/16/97.

Figures

Figure 1. Each layer of the FPS is made of interlocking scintillating strips of triangular cross section. A single charged particle stimulates photon emission in a pair of strips. This track deposits on average 1 times minimum ionizing. The distance from center strip to center strip is about 5 mm. (Triangle base is 10 mm.)
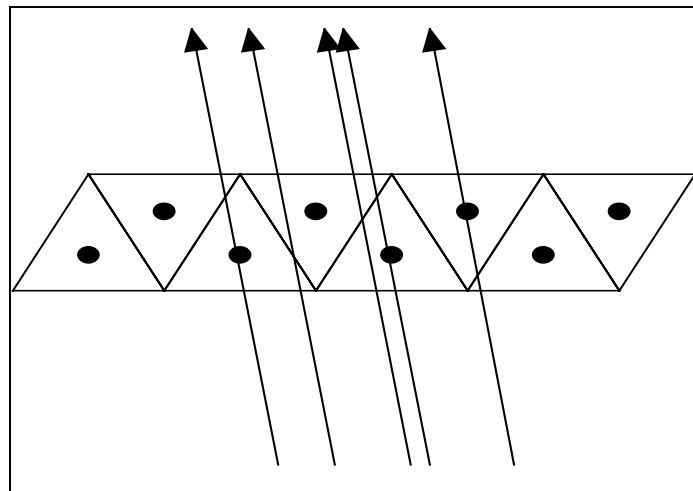

Figure 2. An electron shower is composed of several charged particles which stimulates photon emission in a band of strips. Each track on average deposits over 4 times minimum ionizing.
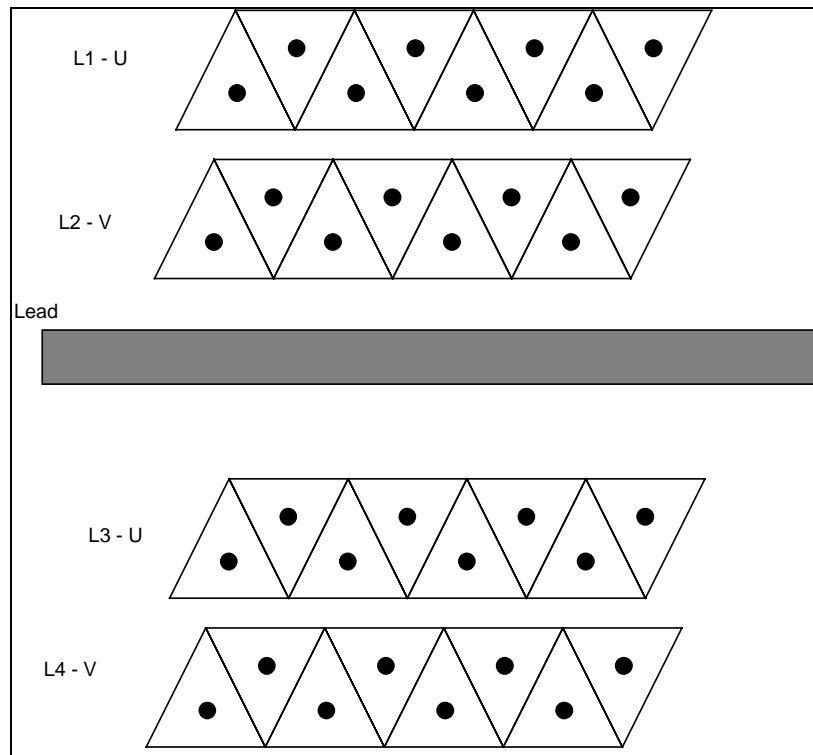
Figure 3. The detector is constructed of four layers of scintillator. Two in front of a lead radiator and two behind. Each pair of layers has a U layer and a V layer. The stereo layers allow the reconstruction of a clusters eta and phi coordinates.
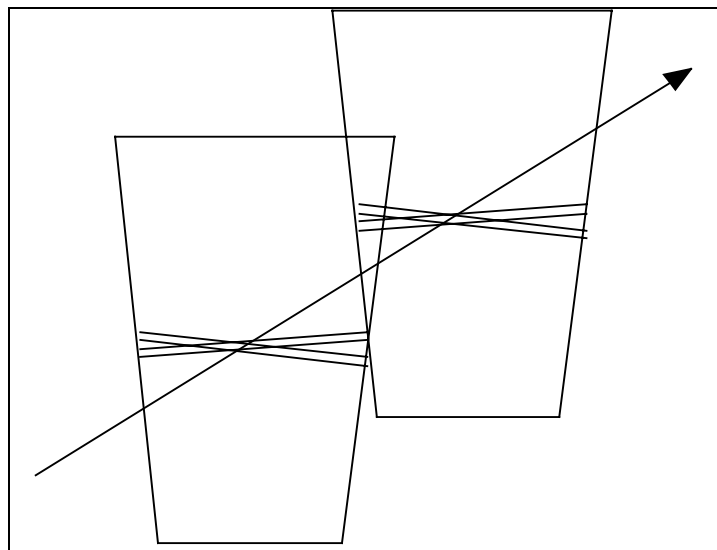

Figure 4. A cluster in each of the U and V layers produce a diamond shaped 'hit' in the detector. A straight line from the forward diamond to the back diamond constitutes a track.